JC943 U.S. PTO
11/06/00

11-08-00 A

Please type a plus sign (+) inside this box [+]

PTO/SB/05 (12/97)
Approved for use through 09/30/00. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

jc915 U.S. PTO
09/707490
11/06/00

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. 001340.P016 Total Pages 2

First Named Inventor or Application Identifier Thorkell Gudmundsson, et al.

Express Mail Label No. EL672752085US

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. X Specification (Total Pages 49)
(preferred arrangement set forth below)
- Descriptive Title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claims
- Abstract of the Disclosure

3. X Drawings(s) (35 USC 113) (Total Sheets 9)

4. X Oath or Declaration (Total Pages 5)

a. X Newly Executed (Original or Copy)

b. ___ Copy from a Prior Application (37 CFR 1.63(d))
(for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**

i. ___ DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. ___ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ___ Microfiche Computer Program (Appendix)

7. __ Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ____ Computer Readable Copy
b. ____ Paper Copy (identical to computer copy)
c. ____ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. X Assignment Papers (cover sheet & documents(s))
9. __ a. 37 CFR 3.73(b) Statement (where there is an assignee)
__ b. Power of Attorney
10. __ English Translation Document (if applicable)
11. __ a. Information Disclosure Statement (IDS)/PTO-1449
__ b. Copies of IDS Citations
12. __ Preliminary Amendment
13. X Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14. __ a. Small Entity Statement(s)
b. Statement filed in prior application, Status still proper and desired
15. __ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. __ Other: _____

17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:
___ Continuation ____ Divisional ____ Continuation-in-part (CIP)
of prior application No: _

18. **Correspondence Address**
_____ Customer Number or Bar Code Label _____ (Insert Customer No. or Attach Bar Code Label here)
or
X Correspondence Address Below

NAME Florin Corie, Reg. No.: 46,244 11/06/2000
BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
ADDRESS 12400 Wilshire Boulevard
Seventh Floor
CITY Los Angeles STATE California ZIP CODE 90025-1026
Country U.S.A. TELEPHONE (408) 720-8598 FAX (408) 720-9397

PTO/SB/17(08-00)
Approved for use through 10/31/2002. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL FOR FY 2001

TOTAL AMOUNT OF PAYMENT ($) $ 2000.00

Complete if Known:
Application No. ******
Filing Date 11/6/2000
First Named Inventor Thorkell Gudmundsson, et al.
Group Art Unit ******
Examiner Name ******
Attorney Docket No. 001340.P016

jc915 U.S. PTO
09/707490
11/06/00

METHOD OF PAYMENT (check one)

1. [X] **The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:**

Deposit Account Number 02-2666
Deposit Account Name

[] **Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17**

2. X **Payment Enclosed:**
X **Check**
____ **Money Order**
____ **Other**

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility application filing fee	710.00
106	320	206	160	Design application filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional application filing fee	

SUBTOTAL (1) $ 710.00

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims	85	– 20** =	65	X	18.00	=	1170.00
Independent Claims	4	– 3** =	1	X	80.00	=	80.00
Multiple Dependent						=	

**Or number previously paid, if greater; For Reissues, see below.

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) $ 1250.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Small Entity

Fee Code	Fee ($)	Fee Code	Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	390	216	195	Extension for response within second month	
117	890	217	445	Extension for response within third month	
118	1,390	218	695	Extension for response within fourth month	
128	1,890	228	945	Extension for response within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,240	241	620	Petition to revive unintentionally abandoned application	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40.00
146	710	246	355	For filing a submission after final rejection (see 37 CFR 1.129(a))	
149	710	249	355	For each additional invention to be examined (see 37 CFR 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	
Other fee (specify)					
Other fee (specify)					
				SUBTOTAL (3)	$ 40.00

*Reduced by Basic Filing Fee Paid

SUBMITTED BY:

Typed or Printed Name: Florin, Corie

Signature: _____ Date: November 6, 2000

Reg. Number: 46,244 Telephone Number: 408-720-8300

"Express Mail" mailing label number: EL672752085US

Date of Deposit: November 6, 2000

I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and that this paper or fee has been addressed to the Assistant Commissioner for Patents, Washington, D. C. 20231

Kristin Baker

(Typed or printed name of person mailing paper or fee)

(Signature of person mailing paper or fee)

11/6/00

(Date signed)

Attorney Docket: 001340.P016 *PATENT*

UNITED STATES PATENT APPLICATION

FOR

APPARATUS FOR COMPUTER-AIDED DESIGN OF A PRODUCT OR PROCESS

INVENTORS:

THORKELL GUDMUNDSSON
MARK ERICKSON
SUNIL C. SHAH

PREPARED BY:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
12400 WILSHIRE BOULEVARD
SEVENTH FLOOR
LOS ANGELES, CA 90025-1026

(408) 720-8300

"Express Mail" mailing label number EL672752085US

Date of Deposit November 6, 2000

I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Kristin Baker
(Typed or printed name of person mailing paper or fee)

Kristin Baker 11/6/00
(Signature of person mailing paper or fee) *Date*

APPARATUS FOR COMPUTER-AIDED DESIGN OF A PRODUCT OR PROCESS

REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of application Serial Number 09/199,708, titled "Method for Computer-Aided Design of a Product or Process," filed on November 24, 1998, still pending; which is a continuation of U.S. Patent No. 5,880,959, titled "Method for Computer-Aided Design of a Product or Process," issued on March 9, 1999.

This application also claims the benefit of U.S. Provisional Application No. 60/186,832, filed on March 3, 2000.

FIELD OF THE INVENTION

The present invention relates generally to system design and control techniques, and, more particularly, to an apparatus for computer-aided design of a product or process.

BACKGROUND OF THE INVENTION

The design and manufacture of new products is becoming an increasingly complex activity because users of such products are demanding an increased number of high performance features that require advanced signal processing and feedback control. Many industries today also rely on complex processes to manufacture a product that also require advanced signal processing and feedback control.

Designing advanced signal processing and control products for dynamic systems is a complicated process. The process involves complex computational algorithms, a complex sequence of design tasks, difficult decision-making, data management, data visualization, and project planning.

This situation presents a challenge for those designing products and control systems, in part because the standard methodologies and apparatuses for design of products and control systems are inadequate in several respects. Many modern products and manufacturing processes are too complex and cannot be satisfactorily controlled by standard control methods and apparatuses. Typical prior (or standard) design methods and apparatuses are linear plans that do not provide alternatives required by the uncertainty of outcomes of computations and tests, and then permit planning based on resource utilization. Also, these prior methods and apparatuses do not incorporate actual experienced results of process execution and adjust projections accordingly.

It is difficult, if not impossible, to achieve satisfactory results using prior methods and apparatuses. There are many problems in applying such methods and apparatuses to complicated manufacturing processes or control of behavior of high performance products.

Prior methods and apparatuses implemented in design tools are not effective for several reasons. For example, prior design tools typically automate linear fragments of the design activity. Results of design steps are thus

unknown or uncertain before the steps are actually carried out. For instance compute time, computational errors, and exceptions, and results of physical tests cannot be known in advance to aid in decision making. These prior tools require a user to make a large number of complex decisions that depend on results of many previous steps. This is a disadvantage because the user must usually possess specific knowledge or skills in order to properly use the information gained from execution of previous steps. It is a further disadvantage because intelligent decisions can only be made and incorporated after waiting for execution of design steps. No problem-specific guidance is available from prior tools for projecting with any accuracy what the results of design steps will be.

Prior design steps can become infeasible or highly optimal because of a user decision made many steps back. Prior design tools cannot help the user see future implications of current decisions. For these reasons, with prior tools, the user must learn by problem-specific experience, over a long period of time, to resolve unknowns and dependencies across design steps.

Effective execution of this process requires expertise in signal processing and/or control theory, in-depth knowledge about the characteristics of the system to be compensated through the product, and awareness of cost-benefit tradeoffs at different stages of the design. Meeting these requirements simultaneously becomes a difficult task.

This problem is further exacerbated by a current division and separation of skill sets among those involved in the design process. For instance, control experts often do not have an in-depth knowledge of the process they are seeking to control. In addition, the proprietary nature of the processes often does not allow for acquisition of an in-depth knowledge of the process. On the other hand, process experts may know conventional control methods but do not know advanced control methods. Existing control design tools are designed for control experts, but are not suitable for process experts.

Experienced control scientists have found ways to sidestep or solve these problems in specific cases. Significant shortcomings still surface, however, when less experienced control designers or team members from other disciplines apply existing software tools to manufacturing and design problems. Consequently, current tools are inadequate for widespread use.

Most existing software design tools simply automate fragments of standard design methods. In general, the tools are ineffective when applied to control of manufacturing processes fro the reasons described above.

Advanced signal processing and control design is typically done with the help of computational tools, such as Matlab®, available from Mathworks, Inc., Natick, Massachusetts, with its associated toolboxes. The Matlab® environment provides a collection of functions to a user for solving certain types of tasks. These functions are not linked in a unified environment and using them requires a high level of expertise in compensator theory. At the

same time, these functions do not provide integrated planning or decision support, task scheduling, or data management.

SUMMARY OF THE INVENTION

An apparatus for computer-aided design of a product or process is described. The apparatus includes a template module for storing a plurality of tasks and a plurality of rules for designing the product. The apparatus further includes a processing module coupled to the template module and being configured by the plurality of rules, for executing the plurality of tasks.

Other features and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings in which:

Figure 1 is a block diagram of one embodiment of an apparatus for computer-aided design of a product or process.

Figure 2 is a block diagram of one embodiment of a processing module within the apparatus.

Figure 3 is a block diagram of one embodiment of a template module within the apparatus.

Figure 4 is a flow diagram of one embodiment of a process managed by a scheduler module within the processing module of the apparatus.

Figure 5 is a flow diagram of one embodiment of a process managed by a planner module within the processing module of the apparatus.

Figure 6 illustrates an exemplary window for a display presented by a presentation module within the processing module of the apparatus.

Figure 7 illustrates an exemplary window for a display that the presentation module may use to present a user with guidance for a design decision.

Figure 8 is a flow diagram of one embodiment of a design flow within the template module of the apparatus.

Figure 9 is a diagram of one embodiment of planning and guidance rules within the template module.

Figure 10 is a flow diagram of one embodiment of a design flow for a load data task performed by the template module within the apparatus.

DETAILED DESCRIPTION

In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be evident, however, to one skilled in the art that the present invention may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form, rather than in detail, in order to avoid obscuring the present invention. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, mechanical, electrical and other changes may be made without departing from the scope of the present invention.

Some portions of the detailed descriptions that follow are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of acts leading to a desired result. The acts are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer

to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The present invention can be implemented by an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general purpose computer, selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or

optical cards, or any type of media suitable for storing electronic instructions, and each coupled to a computer system bus.

The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required operations. For example, any of the operations of the apparatus according to the present invention can be implemented in hard-wired circuitry, by programming a general purpose processor or by any combination of hardware and software. One of skill in the art will immediately appreciate that the invention can be practiced with computer system configurations other than those described below, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. The invention can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. The required structure for a variety of these systems will appear from the description below.

The operations of the apparatus of the invention may be implemented using computer software. If written in a programming language conforming to a recognized standard, sequences of instructions designed to implement the operations can be compiled for execution on a variety of hardware platforms

and for interface to a variety of operating systems. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein. Furthermore, it is common in the art to speak of software, in one form or another (e.g., program, procedure, application...), as taking an action or causing a result. Such expressions are merely a shorthand way of saying that execution of the software by a computer causes the processor of the computer to perform an action or produce a result.

An apparatus for designing a product or process is described. The apparatus may be used for any product design flow or sequence of tasks. The apparatus integrates a computational environment, real-time planning environment, user presentation, design flow, task scheduling, execution, and data management with computer-encoded design expertise. Additionally, the apparatus provides rules for formulating a design flow and creating a template for a specific problem. Finally, the apparatus operates in an environment that is familiar to the design engineer and which allows rapid development and customization.

Figure 1 is a block diagram of one embodiment of an apparatus for computer-aided design of a product or process. As illustrated in Figure 1, in one embodiment, design apparatus 100 includes a template module 110 and a

processing module 120, coupled to the template module 110. Processing module 120 is responsible for the execution procedures of the apparatus.

Figure 2 is a block diagram of one embodiment of a processing module within the apparatus. According to one embodiment illustrated in Figure 2, processing module 120 includes a scheduler module 210, a planner module 220, a presentation module 230, and a computation module 240. In this embodiment, all modules interact directly with each other. However, it should be noted that it is not necessary for each module to directly interact with every other module listed above and that various combinations of interactions may be used depending upon the particular product or process being designed.

In one embodiment, scheduler module 210 runs the entire design process, using a Matlab® environment, or a similar environment. Scheduler module 210 operates using a set of instructions provided by template module 110 shown in Figure 1. Scheduler module 210 may perform one or more of the following functions, either individually or simultaneously: command interpretation, task scheduling, algorithm execution, data management, and/or presentation. Scheduler module 210 is supported by planner module 220, which provides guidance and planning support to the scheduler module 210.

In one embodiment, scheduler module 210 manages the execution tasks of the design apparatus of the present invention. Scheduler module 210 incorporates multiple functions, for example initializing a project (i.e., the product or process to be designed), invoking the correct task at each point in

the design, managing the data between tasks and between design sessions, managing interaction with the planner module 220, managing a main screen display, tracking the progress of the project, and planning the remainder of the project.

In one embodiment, scheduler module 210 organizes data in three categories: persistent data, transient data, and algorithm data. Transient data is data that is created and used with a single task. Persistent data is data that is created by the design apparatus itself, is stored in a data file between sessions, and is recovered when a session is continued after a break. Algorithm data is data that is confined to individual algorithms and is not accessible elsewhere.

Figure 4 is a flow diagram of one embodiment of a process managed by a scheduler module within the processing module of the apparatus. It should be noted that the operations managed by scheduler module 210 and illustrated in Figure 4 may be organized in other equivalent manners and that the flow illustrated is meant merely to be exemplary.

As illustrated in Figure 4, the process starts at processing block 405. At processing block 410, starting instructions are loaded from the template module 110, including a design flow. A design flow is specified in the template module 110 as a sequence of design tasks. Each design task has a set of successor design tasks that may be enabled or disabled based on the state of the design at each time. The design tasks execute individual algorithms as needed, obtain data from the scheduler module 210 or from a user, generate data for the scheduler

module or user, and present their results via the presentation module 230. The design tasks also interact with the planner module 220 for decision guidance and task planning.

At processing block 415, a project to be designed is selected. At processing block 420, a decision is made whether the project selected is a new project or a project that has already been started but for one reason or another the design was stopped before completion. If the project selected is a new project, then the design is initialized, at processing block 428. In one embodiment, initialization of the design includes selection of initial design parameters. If the project is new, in one embodiment of the present invention, the template module 110 provides persistent data that may be used for initialization to the scheduler module 210.

Otherwise, if the project is not new, the design history of the project is loaded, at processing block 427. If the project is not new, in one embodiment of the present invention, the template module 110 provides the scheduler module 210 with the persistent data that was stored when the last session of the design plan for that particular project stopped.

At processing block 430, the planner module 220 is initialized. In one embodiment, in order to initialize the planner module 220, a set of initial parameters for the planner module 220 are selected. As the design of the project progresses, the selected set of initial parameters for the planner module 220 may change. The planner module 220 is described in greater detail below.

Next, at processing block 435, the project is displayed for the user using presentation module 230. The presentation module 230 is described in greater detail below.

At processing block 440, the next design task is run using the task details and algorithms 330 from the template module 110. In one embodiment, the next design task may be a first task to be run after initialization, for example if it is determined that this is a new project. Alternatively, the next design task may be a task subsequent to a last task stored in the design history, for example if the particular project was stopped at one time and the design apparatus is beginning where the project had last been stopped.

Each task specifies a unit operation in the overall design process and each task is usually focused around a single user interaction. However, the task may require any number of computational operations. It should be noted that the task being run may utilize the presentation module 230 and the computation module 240. Some tasks may also involve decision making by the user. In these instances, the user may refer to the planner module 220 to provide some guidance in making the decisions. For example, the user may look to the planner module 220 for cost estimates of making a certain decision or the progress assessment of the overall design if a particular decision is made.

At processing block 445, the planner module 220 is updated. In one embodiment, the template module 110 contains guidance information and planning information needed to update the planner module 220. If the planner

module is the Real-Time Planner described above, which utilizes a Bayesian Belief Network computational engine, then the guidance and planning rules are provided in the form of one or more Bayesian Belief Networks, each representing a portion of the design flow.

Updating the planner module 220 enables the design apparatus to keep track of the design as it progresses. It also enables the planner module 220 to use the latest available information to provide continuously updated predictions of the effects that the completion of the design task and any decisions that were made may have on the future of the design.

Next, at processing block 450, the design history of the project is updated to contain the design task that was just run.

At processing block 455, the display is updated using the presentation module 230 and the new parameters of the project are displayed for the user. The information available at the completion of each task is used by the scheduler module 210 to update the predictions of the remaining tasks, update the assessment of the state of the design, as well as selecting the next task in the sequence.

At processing block 460, a decision is made whether the design session must end and no more tasks are to be performed or if additional design tasks need to be run. In one embodiment, if the design session ends, the procedure stops at processing block 465. The design session may end whether or not the design has been completed and the objective has been met. If the objective has

not been met, the design may be continued in a subsequent session and blocks 427 through 460 may be repeated.

Otherwise, if the design session does not end, a new task is selected at processing block 470 and blocks 440 through 460 are repeated. In one embodiment, the template module 110 contains information pertaining to design tasks and possible future tasks. For example, such information may be contained in the design flow within the template module 110.

In one embodiment, the planner module 220 is coupled to the scheduler module 210. The planner module may provide functions such as: decision guidance, project planning and tracking support, and probabilistic assessment of the state of the design process. It should be noted that it is not necessary for planner module 220 to provide all the features listed above and that various combinations of features may be used depending upon the particular product or process being designed. An example of a planner module 220 is described in detail in U.S. Patent Application Serial No. 09/345,172, filed June 30, 1999, entitled "Real-Time Planner for Design," to Sunil C. Shah, Pradeep Pandey, Thorkell Gudmundsson, and Mark Erickson, and assigned to the assignee herein. Alternatively, other methods and tools may be provided to make the required complex decisions.

In one embodiment, the planner module 220 provides decision guidance by quantifying the utility of making a certain decision and/or recommending the best decision at a decision point. In order to accomplish this, the planner

module 220 quantifies the utility of making a certain decision. The planner module may recommend the best decision at a decision point and/or may rank the alternative decisions based upon the quantification of the decisions.

The planner module 220 may also provide project tracking and planning. Planner module 220 performs this function by tracking any completed tasks and using the state of the design to predict what tasks are needed to complete the design and in what sequence.

Additionally, the planner module 220 may provide probabilistic assessment by collecting information as the design progresses. In one embodiment of the present invention, the rules and/or instructions that the planner module 220 uses for quantification, prediction, and/or assessment of the state of the design may be provided in the template module 110. The planner module 220 may use the presentation module 230 to relay this information to the user.

Figure 5 is a flow diagram of one embodiment of a process managed by a planner module within the processing module of the apparatus. The process starts at processing block 505 when the scheduler module 210 initializes the planner module 220, as described above at processing block 430 of Figure 4. As illustrated in Figure 5, at processing block 510, the planner module 220 loads the planning and guidance rules 320 from the template 110. The planner module 220 then predicts the remaining tasks, i.e., determines the plan for completing the design, at processing block 520.

Next, at processing block 530, the planner module provides guidance for the next decision that needs to be made. At processing block 540, the planner module 220 obtains the actual decision made by the user, and subsequently uses this information to update the prediction (or plan) accordingly at processing block 550. After the task has been completed, at processing block 560, the planner module obtains the results of the performance of the design task, and then diagnoses those results at processing block 570.

At processing block 580, a determination of whether or not the design is complete is made. In one embodiment, if the design is complete, then the planner module 220 stops at processing block 585. Otherwise, if the design is not complete, the planner module 220 updates the plan by predicting the remaining tasks, thus processing blocks 520 through 580 being repeated. It is to be understood that planner module 220 may also stop if the design is not complete and may restart in a subsequent session.

Referring back to Figure 2, in one embodiment, presentation module 230 is coupled to the planner module 220. Presentation module 230 may display the progress of the design, the set of tasks that are expected or needed to complete the design, and incurred and expected project costs. It should be noted that it is not necessary for presentation module 230 to display all of the objectives listed above and that various combinations of objectives may be displayed depending upon the particular product or process being designed. It should also be noted that the presentation module 230 may display any of the

above objectives either singularly or simultaneously depending upon the desire of the user.

In another embodiment, the presentation module 230 may also display an assessment of the current quality of the design. In yet another embodiment, the presentation module 230 may present guidance for making design decisions, display instructions for performing each task, and/or display the results of completed tasks. An example of a presentation module is described in detail in U.S. Patent Application Serial No. 09/346,401, filed June 30, 1999, entitled "A Method and Apparatus for Presentation of Integrated Project Planning and Computer Aided Design," to Thorkell T. Gudmundsson, John M. Cooney, Sunil, C. Shah, and Mark A. Erickson, and assigned to the assignee herein. Alternatively, other tools and methods may be used to display the desired progress information and/or results.

Figure 6 illustrates an exemplary window for a display presented by a presentation module within the processing module of the apparatus. As illustrated in Figure 6, presentation module 230 uses a window 600 to display the design progress, design plan, and design status of the particular project. Window 600 of Figure 6 is updated periodically by the scheduler module 210, as described above at processing block 455 of Figure 4. It should be noted that the display presented by presentation module 230 in window 600 is merely meant to be exemplary and that other information may also be displayed depending upon the particular project and needs of the particular user.

In the embodiment illustrated in Figure 6, window 600 displays a task list 610 which is a combined list of completed tasks and tasks expected to be needed to complete the design. As illustrated in this example, the current task is indicated by a double caret 620. In this particular embodiment, window 600 also displays the cost incurred and expected, in the form of different time measurements shown as element 630. For example, the cost factors of this particular embodiment are a compute time 631, a design time 632, and an equipment time 633. It should be noted that the cost factors illustrated in Figure 6 are meant merely to be exemplary, that other cost factors may be used, and that the cost factors may be quantified in other manners rather than time, for example currency, manpower, or other resources.

As illustrated in Figure 6, in one embodiment, window 600 further displays the status of the current design project in an element 640. In one embodiment, window 600 displays the current quality of the design and the design conditions using multiple bars. The length of the bars indicate the current estimate of the quality of a particular condition. For example, in the case of a controller, a short bar indicates that the performance of the controller is estimated as insufficient. Additionally, window 600 may display interactive buttons 650 for controlling the execution of the design apparatus. It should be noted that the buttons 650 for controlling the execution of the design apparatus may include various control operations, and that the buttons illustrated in

Figure 6: K>>, Stop, Save, and Load, are merely examples used for illustrative purposes only.

Figure 7 illustrates an exemplary window for a display that the presentation module may use to present a user with guidance for a design decision. As shown in Figure 7, in one embodiment, window 700 displays options 710, which embody the choices available to the user. In this embodiment, options 710 include: an option for aggressive design 711, an option for conservative design 712, and an option to go on to perform more analysis 713.

As illustrated in Figure 7, window 700 also displays a box 720 containing instructions for each option that can be displayed. In one embodiment, presentation module 230 uses window 700 to display a cost value 730 assigned to each option 710. The cost value 730 for each option 710 is obtained from the planner module 220. In this embodiment, the option recommended by the design apparatus is the one with the lowest cost, however, the user can override this recommendation and select another option.

Referring back to Figure 2, computation module 240 is coupled to the scheduler module 210 and is accessed by the scheduler module 210 when necessary. In one embodiment, the computation module 240 performs design computations. In alternate embodiments, the computation module 240 may perform any number of functions such as: simulations, data analysis, and/or file handling. It should be noted that the computation module 240 may

perform any number of the functions described above, either individually or in combination, depending upon the particular product or process being designed.

The computation module 240 may further include utilities such as: utilities for manipulating data files; utilities for performing basic linear algebra computations; utilities for performing simulations; utilities for performing data analysis; displays for simultaneously displaying results, displaying guidance, and prompting for a decision; and/or displays for loading and saving data files. If provided in a particular embodiment, these utilities may be used by the design tasks as needed. The utilities may also be combined in variations depending upon the requirements of the particular product or process being designed. The presentation module 230 and computation module 240 may be used by the tasks as needed.

Figure 3 is a block diagram of one embodiment of a template module within the apparatus. In one embodiment illustrated in Figure 3, template module 110 incorporates the expertise necessary to properly execute the design. In one embodiment, this expertise is computer-encoded in the form of instructions and rules that the processing module 120 follows during execution. For example, in one embodiment, the expertise is arranged into three categories: a design flow 310, planning and guidance rules 320, and task details and algorithms 330. It should be noted that the template module 110 may be specific to a certain type of design method or to a certain type of application, or

may apply to different applications. In other embodiments, the template module 110 may also include instructions and rules for the planner module 220.

In one embodiment, template module 110 includes rules (template rules) that govern the implementation of the processing module 120 and ensure that the template module 110 is compatible with the processing module 120. The template rules may include rules for: specifying task sequence; specifying task information; specifying guidance and planning; starting and finishing a task; managing data within a task; presentation and user interaction; specifying a task's interaction with the planner module 220; or a combination of any of the above rules.

The instructions and rules contained in the template module 110 are specific to the particular design problem that the apparatus is applied to. Template module 110 is used to encode the design expertise needed to complete the design of the product or process in a set of instructions and rules that the processing module 120 can interpret. Template module 110 may simultaneously include expertise from multiple sources, such as scientists, equipment specialists, and manufacturing specialists.

An example of one embodiment of a template for one particular product design will be described. The product to be designed in the following example is a generic controller. The template instructions and rules will not be described in detail, but rather illustrated through flow diagrams and block diagrams. It should be noted that the following example of a generic controller is not meant

to be limiting on the present invention and that the design apparatus of the present invention may be used to design various products or processes.

Figure 8 is a flow diagram of one embodiment of a design flow within the template module of the apparatus. Each individual block 810-880 represents a series of tasks to be performed. One such block (block 830) is expanded to show the tasks within that series.

As illustrated in Figure 8, at processing block 810, the design is initialized. Next, the first design iteration is configured at processing block 820. A model is identified at block 830. An estimator is synthesized and a controller is synthesized at blocks 840 and 850, respectively. The design is validated experimentally at block 860 and the current status of the design is analyzed at block 870. The sequence 820 through 870 is repeated until the design is completed. Once the system analysis determines that the design is completed then the design flow stops at block 880.

The expansion of block 830 illustrates the underlying tasks required to perform model identification. As shown, model identification block 830 includes four tasks: deciding the identification approach (block 835); generating an experimental recipe (block 836); loading the resulting data (block 837); and designing the model (block 838). It should be noted that the other blocks 810-880 may also be expanded to show the underlying tasks required for each block, however only one block is expanded here for illustrative purposes.

Referring back to Figure 3, template 110 includes planning and guidance rules 320. Figure 9 is a diagram of one embodiment of planning and guidance rules within the template module. As illustrated in Figure 9, in one embodiment, the planning and guidance rules 320 are encoded in a Bayesian Belief Network. In this embodiment, the set of decisions to be made at each design iteration are encoded in blocks ID1 910, Control1 920, and Verify1 930. The status of the design is encoded in blocks Model0 940, Model1 950, Ctrl0 960, Ctrl2 970, and Ctrl3 980. The costs associated with each of the decisions and with the design status are encoded in the blocks cID1 991, cCont1 992, cVerify1 993, and cCtrl3 994, respectively. It should be noted that Figure 9 is an example of planning and guidance rules encoded in a Bayesian Belief Network. Therefore, the set of decisions, the status, and the costs may be different for different tasks and design projects. In other words, the planning and guidance rules will change depending upon the task to be completed and the design project being undertaken.

Referring back to Figure 3, template module 110 also includes task details and algorithms 330. The details of each task and the algorithms required by each task 330 vary greatly from task to task. Figure 10 is a flow diagram of one embodiment of a design flow for a load data task performed by the template module within the apparatus. The "load data" task is described in detail at processing block 837 of Figure 8. The "load data" task starts at processing block 1010. A file name from the user is obtained at processing

block 1020. The task 837 then loads and verifies the correctness of data residing in the file at processing block 1030. Next, data is analyzed at block 1040. For example, data may be analyzed using the computation module 240.

At processing block 1050, a query is made as to whether the file contains any errors. If no errors have been found, then the results are displayed at processing block 1060. Data is subsequently stored for future use at block 1070, and the task completes at block 1090. If errors have been found, then the errors are processed at block 1080 and the task stops at block 1090. In one embodiment, error processing includes displaying of an appropriate error message and requesting regeneration of data or loading of an alternate file. Alternatively, depending on the type and severity of errors, other error processing methods may be used.

It should be noted that the above-described design apparatus of the present invention may utilize methods described in U.S. Patent No. 5,880,959, entitled "Method for Computer-Aided Design of a Product or Process," to Sunil C. Shah and Pradeep Pandey, and assigned to the assignee herein.

In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. An apparatus for designing a product, said apparatus comprising:

a template module for storing a plurality of tasks and a plurality of rules for designing said product; and

a processing module, coupled to said template module and being configured by said plurality of rules, for executing said plurality of tasks.

2. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for specifying a sequence of execution for said plurality of tasks.

3. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for specifying task information for each task of said plurality of tasks.

4. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for specifying guidance and planning for each task of said plurality of tasks.

5. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for specifying a start event and an end event for each task of said plurality of tasks.

6. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for managing data within one task of said plurality of tasks.

7. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for allowing interaction with a user and presenting results to said user.

8. The apparatus according to claim 1, wherein said template module further comprises at least one rule of said plurality of rules for specifying interaction of each task of said plurality of tasks with said processing module.

9. The apparatus according to claim 4, wherein said at least one rule specifying guidance and planning is encoded in a Bayesian Belief Network.

10. The apparatus according to claim 1, wherein said template module further stores a plurality of task details for each task of said plurality of tasks.

11. The apparatus according to claim 1, wherein said template module further stores a plurality of task operations for each task of said plurality of tasks.

12. The apparatus according to claim 1, wherein said processing module further comprises:

a scheduler module for monitoring execution of said plurality of tasks; and

a planner module coupled to said scheduler module for monitoring operation of said scheduler module and said template module.

13. The apparatus according to claim 12, wherein said scheduler module further selects a project incorporating said plurality of tasks and monitors said execution of each task of said plurality of tasks.

14. The apparatus according to claim 13, wherein, while monitoring, said scheduler module further invokes each task of said plurality of tasks,

schedules said each task for said execution, determines completion of said each task, and manages data between consecutive tasks of said plurality of tasks.

15. The apparatus according to claim 13, wherein, while selecting, said scheduler module further assigns a set of project parameters to said project, initializes said planner module with a set of planner parameters, and displays said set of project parameters to a user.

16. The apparatus according to claim 15, wherein said set of project parameters includes initial project parameters provided by said user.

17. The apparatus according to claim 15, wherein said scheduler module further updates said set of planner parameters after completion of said each task of said plurality of tasks.

18. The apparatus according to claim 12, wherein said scheduler module further updates said set of project parameters after completion of said each task of said plurality of tasks to obtain a set of updated project parameters, and displays said set of updated project parameters to said user.

19. The apparatus according to claim 12, wherein said planner module further loads at least one planning and guidance rule of said plurality

of rules from said template module, determines a sequence of execution for said each task of said plurality of tasks based on said at least one planning and guidance rule, and predicts a decision for each task of said plurality of tasks.

20. The apparatus according to claim 19, wherein said planner module further monitors at least one executed task of said plurality of tasks and updates said decision for said each task of said plurality of tasks remaining to be executed.

21. The apparatus according to claim 20, wherein said planner module further obtains at least one result of said at least one executed task of said plurality of tasks and diagnoses said at least one result.

22. The apparatus according to claim 12, wherein said processing module further comprises:

a presentation module coupled to each of said scheduler module and said planner module for displaying information to a user; and

a computation module coupled to each of said presentation module, said scheduler module, and said planner module for performing computations related to said execution of said plurality of tasks.

23. The apparatus according to claim 22, wherein said presentation module further displays a plurality of costs incurred and expected in said execution of each task of said plurality of tasks.

24. The apparatus according to claim 22, wherein said presentation module further displays a plurality of instructions for executing each task of said plurality of tasks.

25. The apparatus according to claim 22, wherein said presentation module further displays results of said plurality of tasks after execution.

26. The apparatus according to claim 22, wherein said computation module further includes a plurality of utilities for manipulating data files within said processing module.

27. The apparatus according to claim 22, wherein said computation module further includes a plurality of utilities for performing said computations.

28. The apparatus according to claim 22, wherein said computation module further includes a plurality of utilities for performing simulations of at least one task of said plurality of tasks within said processing module.

29. The apparatus according to claim 22, wherein said computation module further includes a plurality of utilities for performing data analysis within said processing module.

30. An apparatus for designing a product, said apparatus comprising:

a template module for storing a plurality of tasks and a plurality of rules for designing said product; and

a processing module, coupled to said template module and being configured by said plurality of rules, for executing said plurality of tasks;

said processing module having a scheduler module for monitoring execution of said plurality of tasks, and a planner module coupled to said scheduler module for monitoring operation of said scheduler module and said template module.

31. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for specifying a sequence of execution for said plurality of tasks.

32. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for specifying task information for each task of said plurality of tasks.

33. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for specifying guidance and planning for each task of said plurality of tasks.

34. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for specifying a start event and an end event for each task of said plurality of tasks.

35. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for managing data within one task of said plurality of tasks.

36. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for allowing interaction with a user and presenting results to said user.

37. The apparatus according to claim 30, wherein said template module further comprises at least one rule of said plurality of rules for specifying interaction of each task of said plurality of tasks with said processing module.

38. The apparatus according to claim 33, wherein said at least one rule specifying guidance and planning is encoded in a Bayesian Belief Network.

39. The apparatus according to claim 30, wherein said scheduler module further selects a project incorporating said plurality of tasks and monitors said execution of each task of said plurality of tasks.

40. The apparatus according to claim 39, wherein, while monitoring, said scheduler module further invokes each task of said plurality of tasks, schedules said each task for said execution, determines completion of said each task, and manages data between consecutive tasks of said plurality of tasks.

41. The apparatus according to claim 39, wherein, while selecting, said scheduler module further assigns a set of project parameters to said project, initializes said planner module with a set of planner parameters, and displays said set of project parameters to a user.

42. The apparatus according to claim 41, wherein said set of project parameters includes initial project parameters provided by said user.

43. The apparatus according to claim 41, wherein said scheduler module further updates said set of planner parameters after completion of said each task of said plurality of tasks.

44. The apparatus according to claim 30, wherein said scheduler module further updates said set of project parameters after completion of said each task of said plurality of tasks to obtain a set of updated project parameters, and displays said set of updated project parameters to said user.

45. The apparatus according to claim 30, wherein said planner module further loads at least one planning and guidance rule of said plurality of rules from said template module, determines a sequence of execution for said each task of said plurality of tasks based on said at least one planning and guidance rule, and predicts a decision for each task of said plurality of tasks.

46. The apparatus according to claim 45, wherein said planner module further monitors at least one executed task of said plurality of tasks and updates said decision for said each task of said plurality of tasks remaining to be executed.

47. The apparatus according to claim 46, wherein said planner module further obtains at least one result of said at least one executed task of said plurality of tasks and diagnoses said at least one result.

48. The apparatus according to claim 30, wherein said processing module further comprises:

a presentation module coupled to each of said scheduler module and said planner module for displaying information to a user; and

a computation module coupled to each of said presentation module, said scheduler module, and said planner module for performing computations related to said execution of said plurality of tasks.

49. The apparatus according to claim 48, wherein said presentation module further displays a plurality of costs incurred and expected in said execution of each task of said plurality of tasks.

50. The apparatus according to claim 48, wherein said presentation module further displays a plurality of instructions for executing each task of said plurality of tasks.

51. The apparatus according to claim 48, wherein said presentation module further displays results of said plurality of tasks after execution.

52. The apparatus according to claim 48, wherein said computation module further includes a plurality of utilities for manipulating data files within said processing module.

53. The apparatus according to claim 48, wherein said computation module further includes a plurality of utilities for performing said computations.

54. The apparatus according to claim 48, wherein said computation module further includes a plurality of utilities for performing simulations of at least one task of said plurality of tasks within said processing module.

55. The apparatus according to claim 48, wherein said computation module further includes a plurality of utilities for performing data analysis within said processing module.

56. An apparatus for designing a product, said apparatus comprising:

a template module for storing a plurality of tasks and a plurality of rules for designing said product; and

a processing module, coupled to said template module and being configured by said plurality of rules, for executing said plurality of tasks;

said processing module having a scheduler module for monitoring execution of said plurality of tasks, a planner module coupled to said scheduler module for monitoring operation of said scheduler module and said template module, a presentation module coupled to each of said scheduler module and said planner module for displaying information to a user, and a computation module coupled to each of said presentation module, said scheduler module, and said planner module for performing computations related to said execution of said plurality of tasks.

57. A computer readable medium containing executable instructions, which, when executed in a processing system, cause said system to perform a method comprising:

storing a plurality of tasks and a plurality of rules for designing a product in a template module; and

executing said plurality of tasks in a processing module coupled to said template module and being configured by said plurality of rules.

58. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for specifying a sequence of execution for said plurality of tasks.

59. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for specifying task information for each task of said plurality of tasks.

60. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for specifying guidance and planning for each task of said plurality of tasks.

61. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for specifying a start event and an end event for each task of said plurality of tasks.

62. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for managing data within one task of said plurality of tasks.

63. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for allowing interaction with a user and presenting results to said user.

64. The computer readable medium according to claim 57, wherein said template module further comprises at least one rule of said plurality of rules for specifying interaction of each task of said plurality of tasks with said processing module.

65. The computer readable medium according to claim 60, wherein said at least one rule specifying guidance and planning is encoded in a Bayesian Belief Network.

66. The computer readable medium according to claim 57, wherein said template module further stores a plurality of task details for each task of said plurality of tasks.

67. The computer readable medium according to claim 57, wherein said template module further stores a plurality of task operations for each task of said plurality of tasks.

68. The computer readable medium according to claim 57, wherein said method further comprises:

monitoring execution of said plurality of tasks in a scheduler module within said processing module; and

monitoring operation of said scheduler module and said template module in a planner module coupled to said scheduler module within said processing module.

69. The computer readable medium according to claim 68, wherein said scheduler module further selects a project incorporating said plurality of tasks and monitors said execution of each task of said plurality of tasks.

70. The computer readable medium according to claim 69, wherein, while monitoring, said scheduler module further invokes each task of said plurality of tasks, schedules said each task for said execution, determines completion of said each task, and manages data between consecutive tasks of said plurality of tasks.

71. The computer readable medium according to claim 69, wherein, while selecting, said scheduler module further assigns a set of project parameters to said project, initializes said planner module with a set of planner parameters, and displays said set of project parameters to a user.

72. The computer readable medium according to claim 71, wherein said set of project parameters includes initial project parameters provided by said user.

73. The computer readable medium according to claim 71, wherein said scheduler module further updates said set of planner parameters after completion of said each task of said plurality of tasks.

74. The computer readable medium according to claim 68, wherein said scheduler module further updates said set of project parameters after completion of said each task of said plurality of tasks to obtain a set of updated project parameters, and displays said set of updated project parameters to said user.

75. The computer readable medium according to claim 68, wherein said planner module further loads at least one planning and guidance rule of said plurality of rules from said template module, determines a sequence of execution for said each task of said plurality of tasks based on said at least one planning and guidance rule, and predicts a decision for each task of said plurality of tasks.

76. The computer readable medium according to claim 75, wherein said planner module further monitors at least one executed task of said plurality of tasks and updates said decision for said each task of said plurality of tasks remaining to be executed.

77. The computer readable medium according to claim 76, wherein said planner module further obtains at least one result of said at least one executed task of said plurality of tasks and diagnoses said at least one result.

78. The computer readable medium according to claim 68, wherein said method further comprises:

displaying information to a user by a presentation module coupled to each of said scheduler module and said planner module within said processing module; and

performing computations related to said execution of said plurality of tasks by a computation module coupled to each of said presentation module, said scheduler module, and said planner module within said processing module.

79. The computer readable medium according to claim 78, wherein said presentation module further displays a plurality of costs incurred and expected in said execution of each task of said plurality of tasks.

80. The computer readable medium according to claim 78, wherein said presentation module further displays a plurality of instructions for executing each task of said plurality of tasks.

81. The computer readable medium according to claim 78, wherein said presentation module further displays results of said plurality of tasks after execution.

82. The computer readable medium according to claim 78, wherein said computation module further includes a plurality of utilities for manipulating data files within said processing module.

83. The computer readable medium according to claim 78, wherein said computation module further includes a plurality of utilities for performing said computations.

84. The computer readable medium according to claim 78, wherein said computation module further includes a plurality of utilities for performing simulations of at least one task of said plurality of tasks within said processing module.

85. The computer readable medium according to claim 78, wherein said computation module further includes a plurality of utilities for performing data analysis within said processing module.

ABSTRACT

An apparatus for computer-aided design of a product or process is described. The apparatus includes a template module for storing a plurality of tasks and a plurality of rules for designing the product. The apparatus further includes a processing module coupled to the template module and being configured by the plurality of rules, for executing the plurality of tasks.

Express Mail Label No. EV 339 920 245 US

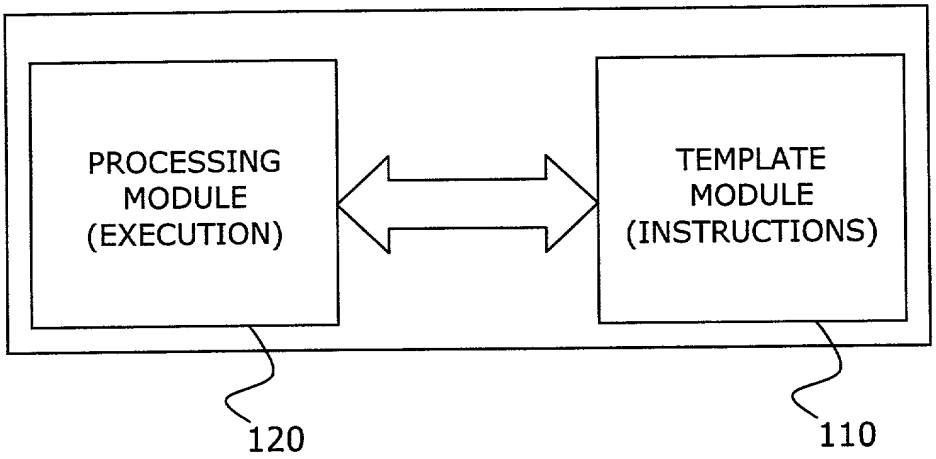

PROCESSING
MODULE
(EXECUTION)
TEMPLATE
MODULE
(INSTRUCTIONS)
120
110

FIG. 1

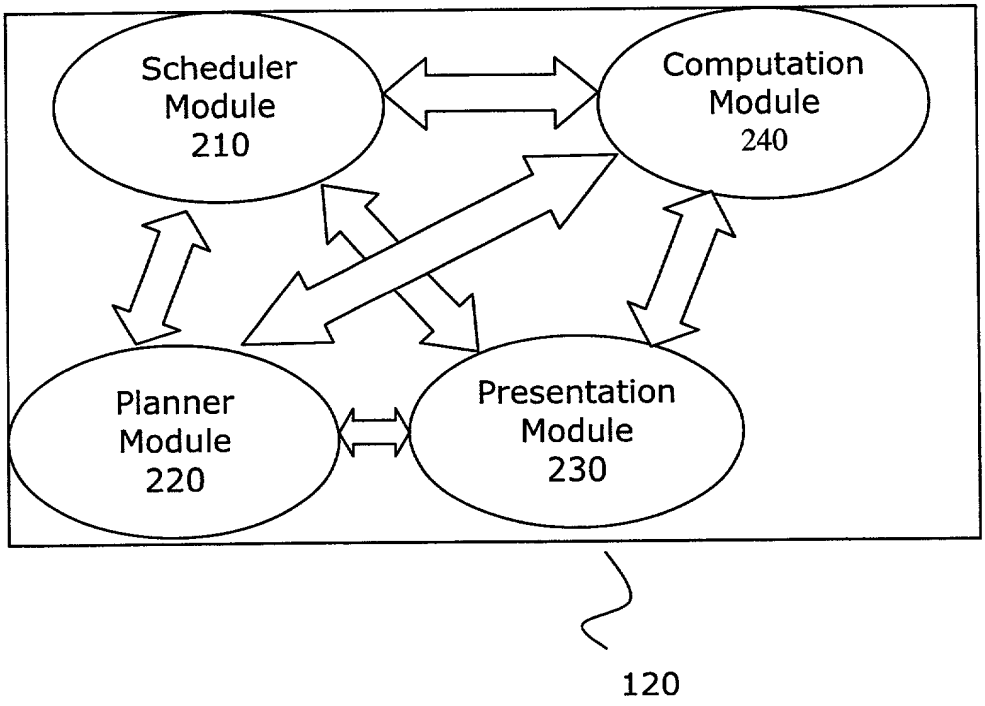

Scheduler
Module
210
Computation
Module
240
Planner
Module
220
Presentation
Module
230
120

FIG. 2

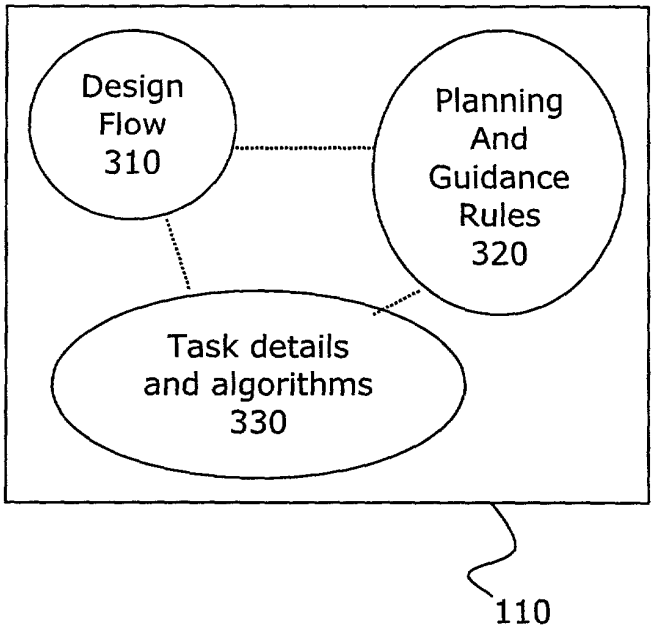

Design
Flow
310
Planning
And
Guidance
Rules
320
Task details
and algorithms
330
110

FIG. 3

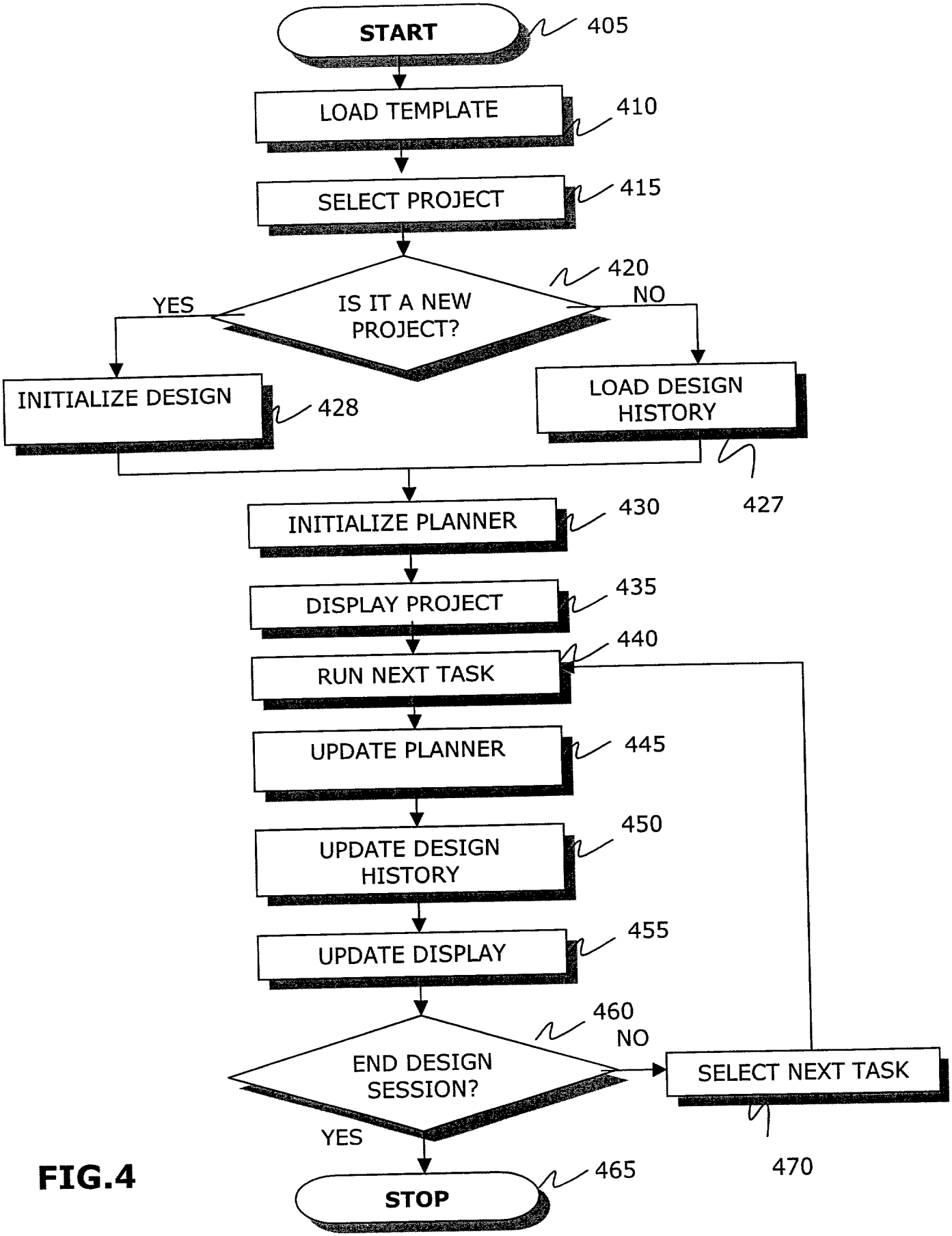

START
405
LOAD TEMPLATE
410
SELECT PROJECT
415
IS IT A NEW PROJECT?
420
YES
NO
INITIALIZE DESIGN
428
LOAD DESIGN HISTORY
427
INITIALIZE PLANNER
430
DISPLAY PROJECT
435
RUN NEXT TASK
440
UPDATE PLANNER
445
UPDATE DESIGN HISTORY
450
UPDATE DISPLAY
455
END DESIGN SESSION?
460
NO
SELECT NEXT TASK
470
YES
STOP
465

FIG.4

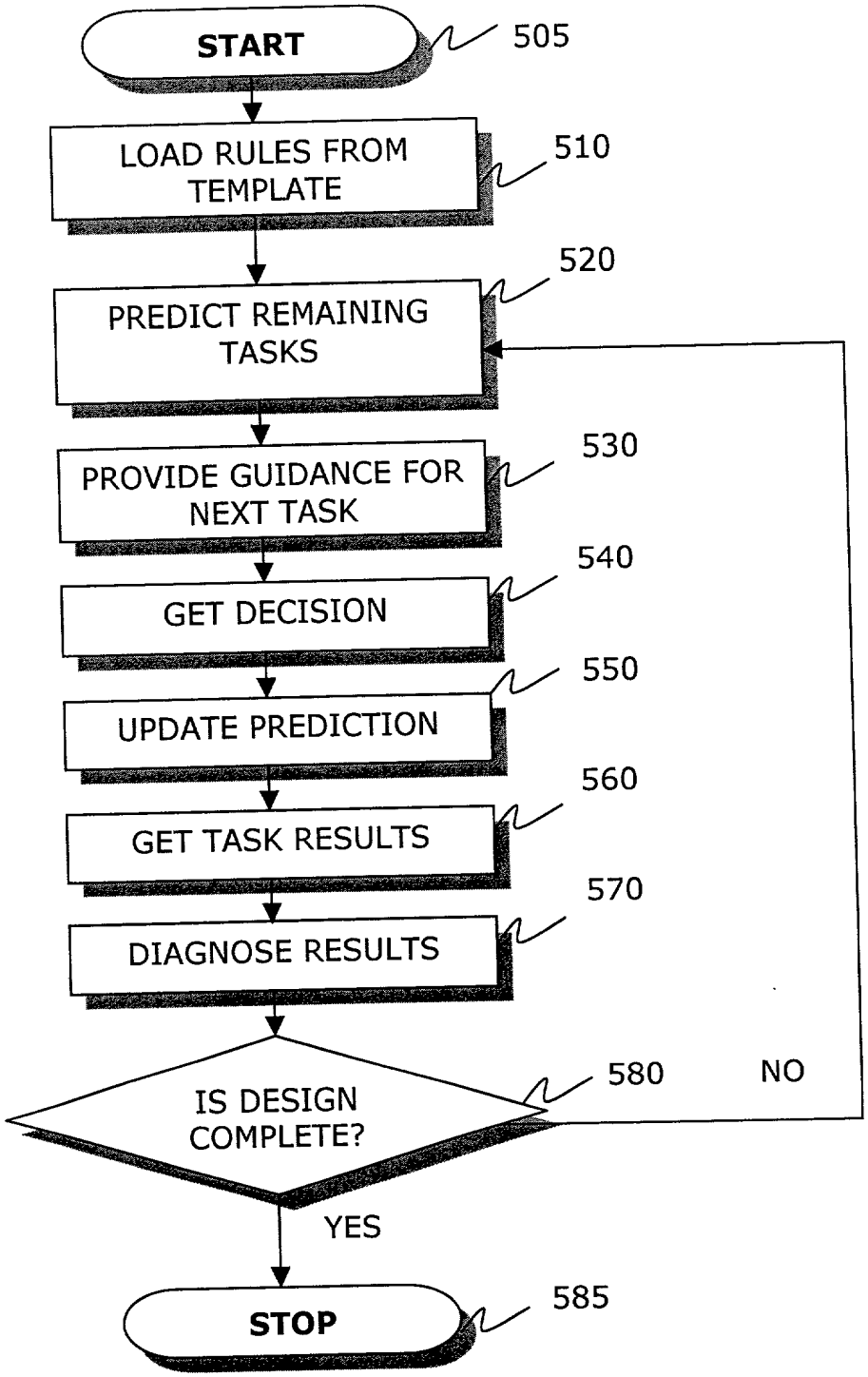

START
505
LOAD RULES FROM TEMPLATE
510
PREDICT REMAINING TASKS
520
PROVIDE GUIDANCE FOR NEXT TASK
530
GET DECISION
540
UPDATE PREDICTION
550
GET TASK RESULTS
560
DIAGNOSE RESULTS
570
IS DESIGN COMPLETE?
580
NO
YES
STOP
585

FIG. 5

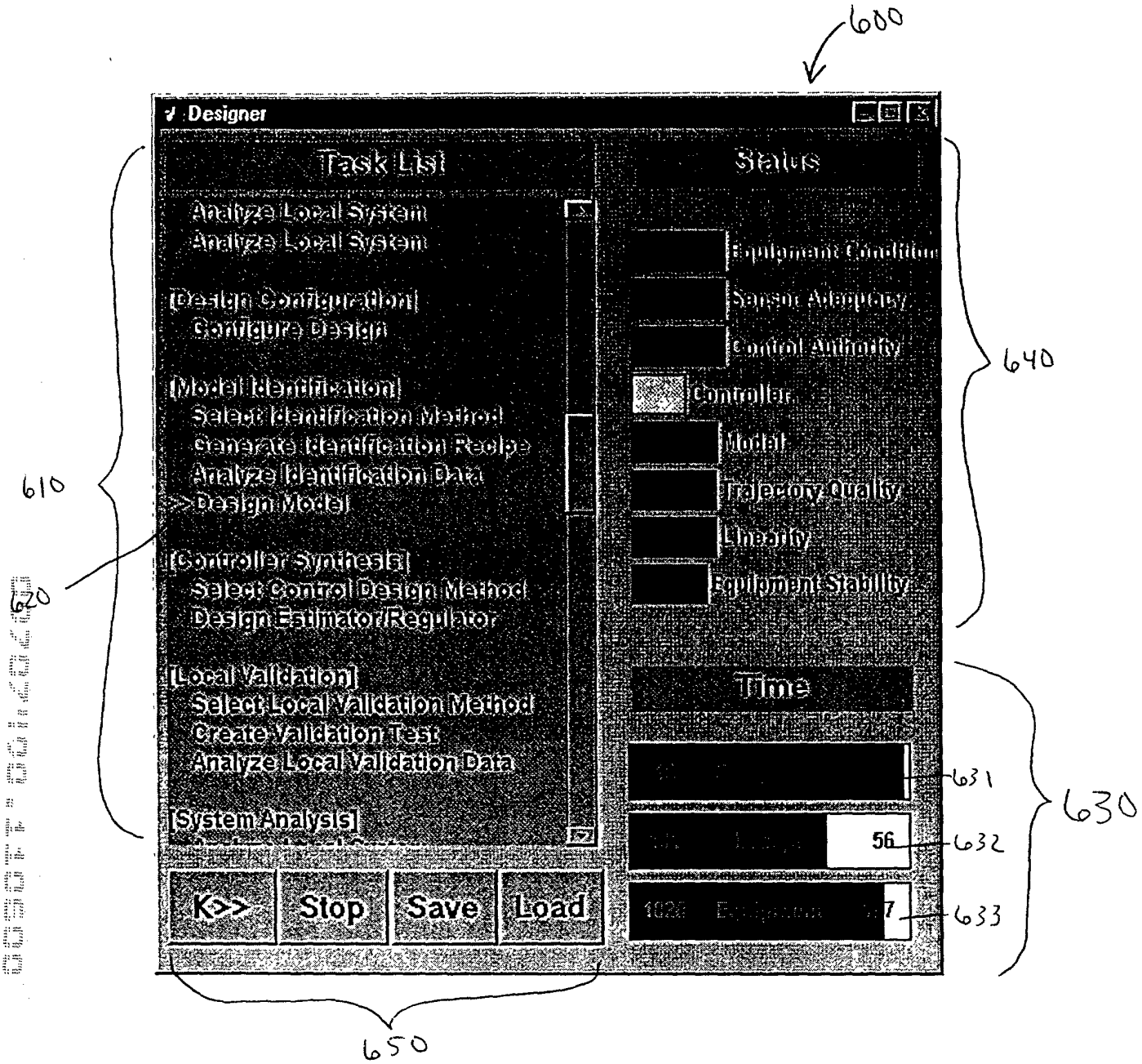

600
Designer
Task List
Status
Analyze Local System
Analyze Local System
[Design Configuration]
Configure Design
[Model Identification]
Select Identification Method
Generate Identification Recipe
Analyze Identification Data
>>Design Model
[Controller Synthesis]
Select Control Design Method
Design Estimator/Regulator
[Local Validation]
Select Local Validation Method
Create Validation Test
Analyze Local Validation Data
[System Analysis]
Equipment Condition
Sensor Adaptory
Control Authority
Controller
Model
Trajectory Quality
Linearity
Equipment Stability
Time
56
7
K>>
Stop
Save
Load
610
620
630
631
632
633
640
650

FIG. 6

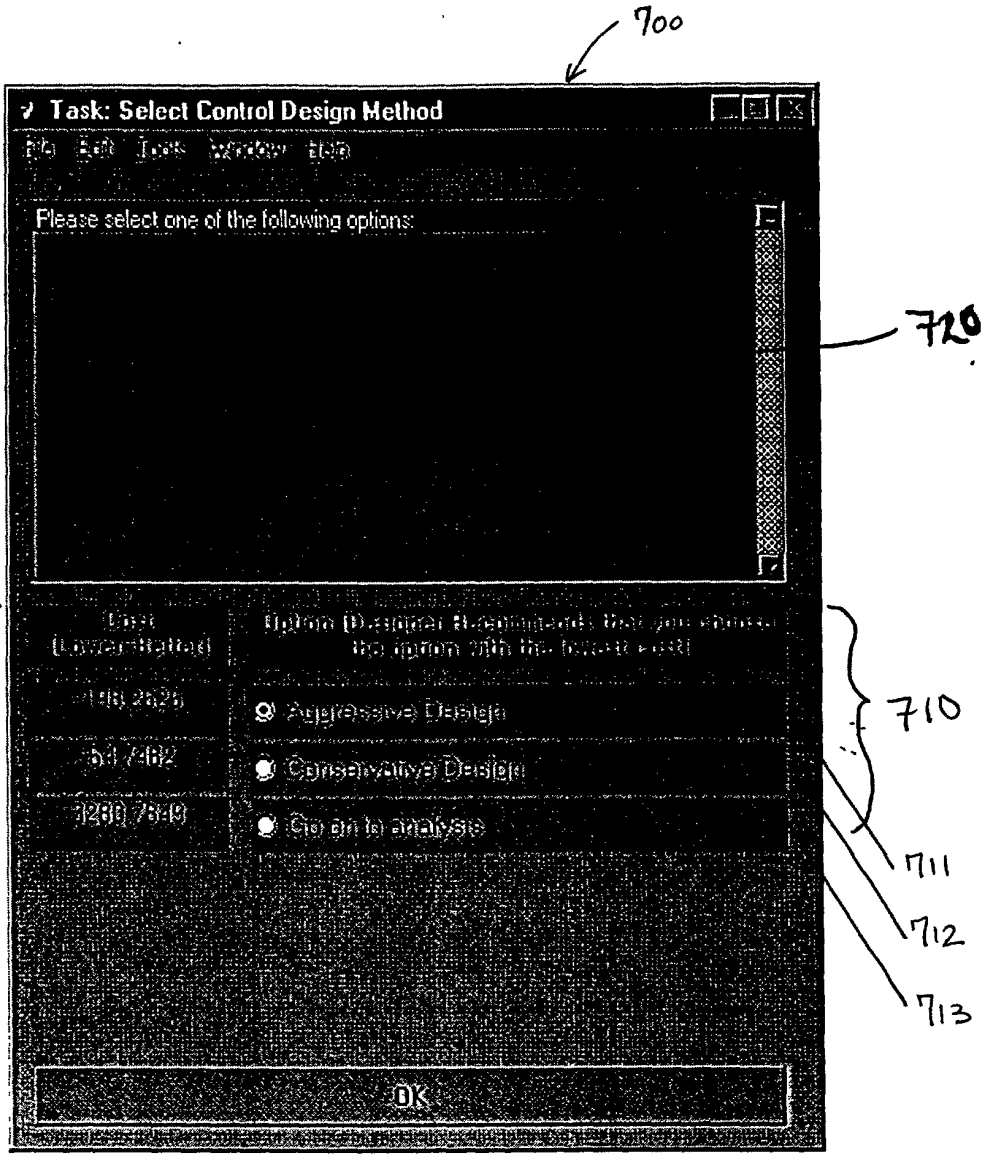

700
Task: Select Control Design Method
Please select one of the following options:
720
Cost (Low=Better)
Option (Designer Recommends that you choose the option with the lowest cost)
Aggressive Design
Conservative Design
Go on to analysis
OK
730
710
711
712
713

Fig. 7

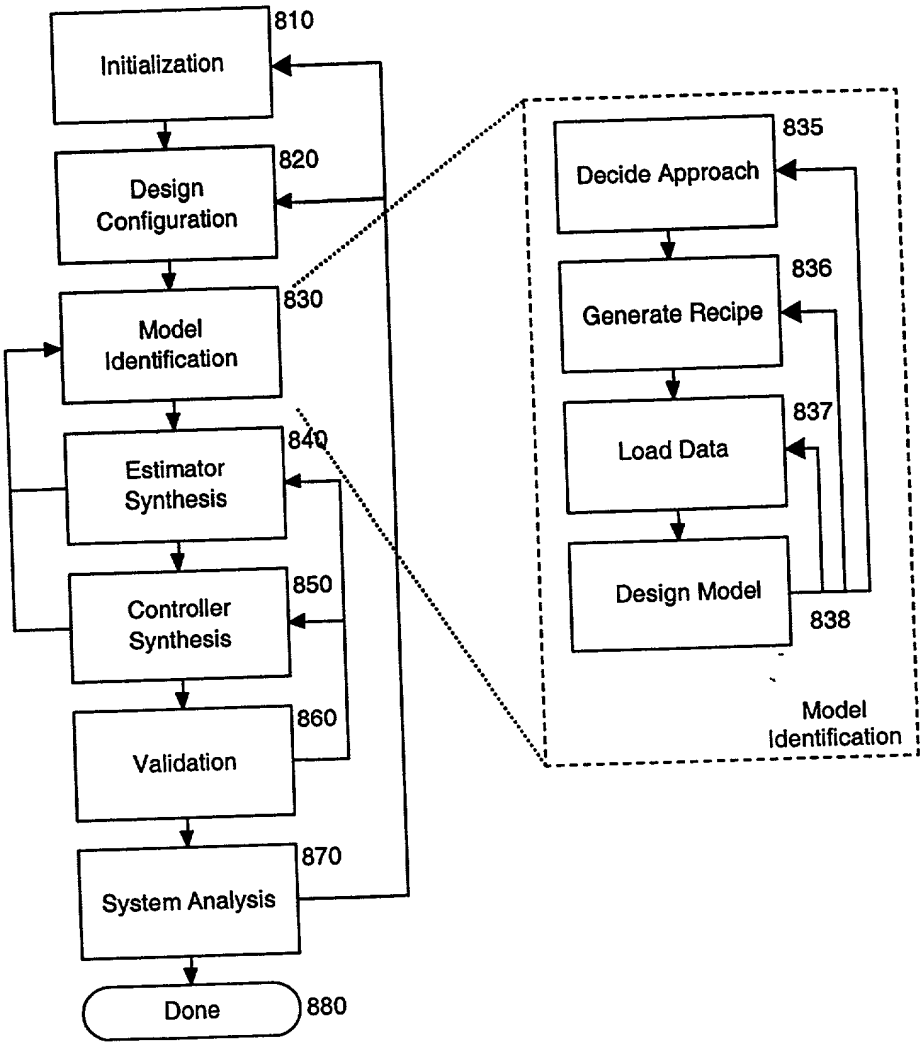

Initialization
810
Design Configuration
820
Model Identification
830
Estimator Synthesis
840
Controller Synthesis
850
Validation
860
System Analysis
870
Done
880
Decide Approach
835
Generate Recipe
836
Load Data
837
Design Model
838
Model Identification

Fig 8

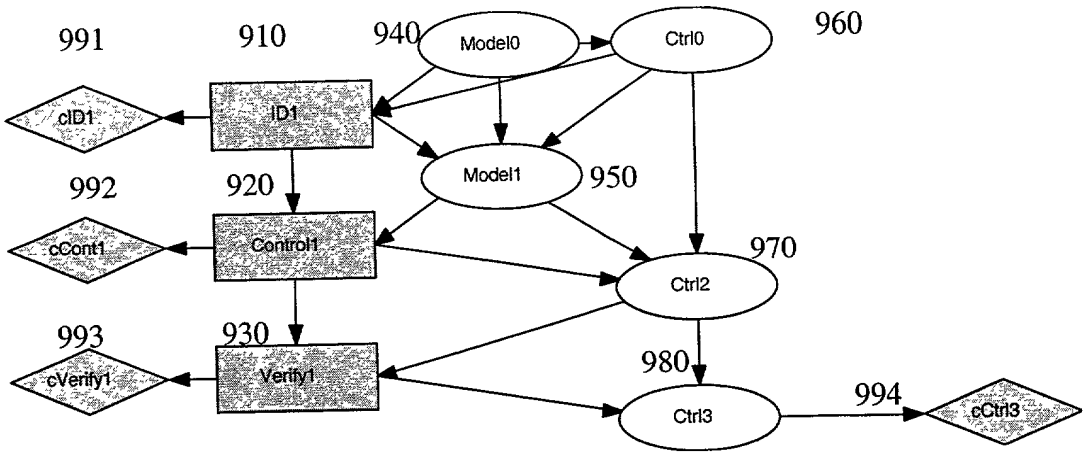

991
910
940
Model0
Ctrl0
960
cID1
ID1
Model1
950
992
920
cCont1
Control1
970
Ctrl2
993
930
980
cVerify1
Verify1
994
Ctrl3
cCtrl3

FIG. 9

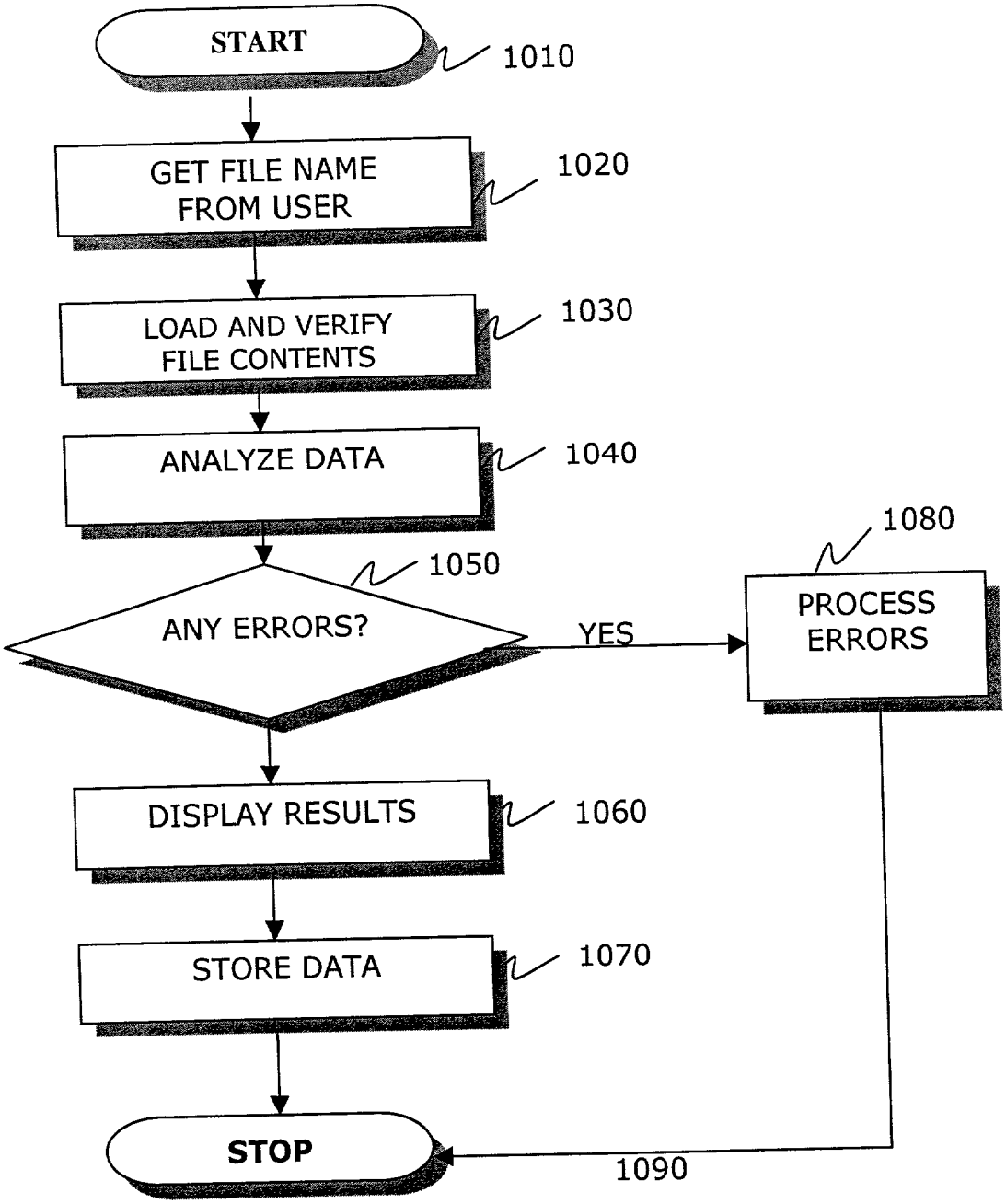

START
1010
GET FILE NAME FROM USER
1020
LOAD AND VERIFY FILE CONTENTS
1030
ANALYZE DATA
1040
1050
ANY ERRORS?
YES
1080
PROCESS ERRORS
DISPLAY RESULTS
1060
STORE DATA
1070
STOP
1090

FIG. 10

APPENDIX A

William E. Alford, Reg. No. 37,764; Farzad E. Amini, Reg. No. P42,261; Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Carol F. Barry, Reg. No. 41,600; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Andrew C. Chen, Reg. No. 43,544; Thomas M. Coester, Reg. No. 39,637; Florin Corie, Reg. No. 46,244; Dennis M. deGuzman, Reg. No. 41,702; Stephen M. De Klerk, under 37 C.F.R. § 10.9(b); Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Robert Andrew Diehl, Reg. No. 40,992; Sanjeet Dutta, Reg. No. P46,145; Matthew C. Fagan, Reg. No. 37,542; Tarek N. Fahmi, Reg. No. 41,402; Paramita Ghosh, Reg. No. 42,806; James Y. Go, Reg. No. 40,621; James A. Henry, Reg. No. 41,064; Willmore F. Holbrow III, Reg. No. P41,845; Sheryl Sue Holloway, Reg. No. 37,850; George W Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; William W. Kidd, Reg. No. 31,772; Sang Hui Kim, Reg. No. 40,450; Eric T. King, Reg. No. 44,188; Erica W. Kuo, Reg. No. 42,775; Kurt P. Leyendecker, Reg. No. 42,799; Michael J. Mallie, Reg. No. 36,591; Andre L. Marais, under 37 C.F.R. § 10.9(b); Paul A. Mendonsa, Reg. No. 42,879; Chun M. Ng, Reg. No. 36,878; Thien T. Nguyen, Reg. No. 43,835; Thinh V. Nguyen, Reg. No. 42,034; Dennis A. Nicholls, Reg. No. 42,036; Daniel E. Ovanezian, Reg. No. 41,236; Marina Portnova, Reg. No. 45,750; Babak Redjaian, Reg. No. 42,096; William F. Ryann, Reg. 44,313; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Jeffrey Sam Smith, Reg. No. 39,377; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Judith A. Szepesi, Reg. No. 39,393; Vincent P. Tassinari, Reg. No. 42,179; Edwin H. Taylor, Reg. No. 25,129; John F. Travis, Reg. No. 43,203; George G. C. Tseng, Reg. No. 41,355; Joseph A. Twarowski, Reg. No. 42,191; Lester J. Vincent, Reg. No. 31,460; Glenn E. Von Tersch, Reg. No. 41,364; John Patrick Ward, Reg. No. 40,216; Mark L. Watson, Reg. No. 46,322; Thomas C. Webster, Reg. No. P46,154; Charles T. J. Weigell, Reg. No. 43,398; Kirk D. Williams, Reg. No. 42,229; Steven D. Yates, Reg. No. 42,242; and Norman Zafman, Reg. No. 26,250; my patent attorneys, and Justin M. Dillon, Reg. No. 42,486; my patent agent, of BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, and James R. Thein, Reg. No. 31,710, my patent attorney.

I also hereby appoint Darren J. Milliken, Reg. No. 42,004 as my attorney of Voyan Technology located at 3255-7 Scott Blvd., Santa Clara, CA 95054, telephone (408)-450-4234 with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.